Petroleum Resources Offshore and Onshore Nova Scotia Canada We're Worth Exploring

Nova Scotia Department of Natural Resources Mineral Resources Branch Information Circular ME 39, 1994

Table of Contents

- We're Worth Exploring!
- Offshore
- Onshore
- In Conclusion

Back to Top

We're Worth Exploring!

Nova Scotia, located on Canada's east coast, is one of North America's most promising and least explored areas for oil and gas (Fig. 1). The operational environment is favourable, being ice-free and similar to that of the North Sea, and is close to energy markets in central and eastern Canada and the northeastern United States. The site of Canada's first offshore oil-producing project, the province boasts a trained labour force and local infrastructure to service the oil and gas industry. The onshore holds the promise of resource potential, where companies have recently acquired rights to explore for oil, natural gas, and coalbed methane, a clean, environmentally friendly energy source.

Figure: (Not presently available)

Figure 1. Nova Scotia in relationship to North America.

The discovered gas reserves in the province's offshore region have been the subject of a recent study be experts to update field development options and costs and to analyze the potential of current and future markets. Phase I of the study suggests that by matching production with market growth, offshore natural gas production could be feasible by the early

2000s. The follow-up work on Phase II is even more optimistic. Similarly, market analysis for coalbed methane shows potential for a strong demand within the next decade.

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For regulatory purposes, oil and natural gas activity in Nova Scotia is divided into offshore and onshore jurisdictions (Fig. 2). The offshore region is administered jointly be the governments of Nova Scotia and Canada. The onshore region is administered solely by the provincial government.

Figure: (Not presently available)

Figure 2. Nova Scotia's offshore and onshore regions.

Offshore

The offshore region covers approximately 40 million hectares. More than 135 wells have been drilled offshore and over 300 000 kilometres (km) of seismic data have been acquired. To date, approximately 182 billion cubic metres (m^3) (6.4 trillion cubic feet) (tcf) of natural gas and 34.5 million m^3 (217 million barrels) of oil and natural gas condensate have been discovered. It has been estimated that this amounts to only 35 per cent of the total natural gas and 20 per cent of the total oil and condensate potential.

The Scotian Shelf is still relatively unexplored, and there are many undrilled prospects. This is particularly true in the Laurentian Sub-basin, which had been under a moratorium pending a resolution of the Canada-France international boundary for St. Pierre and Miquelon. The decision of the International Court of Arbitration in 1992 has removed any uncertainty regarding the international boundary (see Fig. 2), and exploration is expected to resume soon.

Onshore

The onshore region comprises the land mass of the province and certain submarine areas, including the Minas Basin, St. Georges Bay, and Chedabucto Bay (see Fig. 5). One-third of this 6 million hectare area has the geological potential to contain hydrocarbons. Most onshore exploration has concentrated on rocks of Carboniferous age, which extend throughout much of the province and into New Brunswick's Stoney Creek field, an oil and natural gas producer since 1912.

Figure: (Not presently available)

Figure 5. Rocks of the late Carboniferous period.

The province's coalbed methane is being aggressively pursued. Coalbed methane exploration rights have been issued in one coal basin, which, from preliminary estimates, is predicted to contain as much as 170 billion m^3 (6 tcf) of methane. Throughout the province, a number of prolific coal basins contain coals of the right age, rank, and type with the potential to yield this new energy source.

For Further Information

Following is a basic overview of the oil and natural gas exploration and development opportunities for the offshore and onshore regions of Nova Scotia. Additional information may be obtained by contacting the **Petroleum Directorate** (see For more information at the end of this brochure for details).

Back to Top

Offshore

Petroleum exploration offshore Nova Scotia began in 1959 when Mobil Oil Canada, Ltd. was issued the province's first exploration licenses, covering Sable Island (Fig. 2) and the surrounding offshore area. Mobil and its partners drilled the first offshore well on Sable Island in 1967, encountering a thick sedimentary section, 11 natural gas shows, and evidence of light oil. This initiated the first exploration cycle, which lasted until the end of 1978. Although commercial quantities of oil and natural gas were not discovered during this cycle, one significant oil discovery and nine significant natural gas discoveries were made.

A second exploration cycle began when significant quantities of natural gas and condensate were encountered at a discovery well drilled on the Venture structure (see Fig. 3) in 1979. The result of this activity, which peaked during the mid-1980s and ended in 1989, was the discovery of 12 significant natural gas finds and one of oil. In early 1990, a new operator, LASMO Nova Scotia Resources (Ventures) Limited, developed the Cohasset Project, and Canada's first offshore oil project began production on June 3, 1992.

Figure: (Not presently available)

Figure 3. Sable Sub-basin Significant Discoveries.

Geology

The Scotian Shelf is one of Canada's largest sedimentary basins. The thickest accumulation of sedimentary rock capable of producing hydrocarbons is found in the Sable Sub-basin, and most oil and natural gas discoveries have been made there. Although undrilled, the Laurentian Sub-basin appears to be an eastward extension of the Scotian Shelf with a similar depositional, structural, and thermal history. A preliminary assessment of this area indicates that a number of hydrocarbon accumulations large enough to be commercial may exist.

Formations deposited from the Early Jurassic to Late Cretaceous periods are critical to the hydrocarbon potential of the Scotian Shelf and the Sable Island area in particular. The Baccaro bank, a thick, regionally extensive carbonate unit, is largely unexplored and contains several potential plays. While no discoveries have been made within this carbonate unit, reservoir sands occur at shallower depths (2150 and 2400 m) and drape over the bank. In such fields as Cohasset and Panuke, these sands are known to contain commercial accumulations of oil.

Extending through the Sable Sub-basin are units of coarse clastics, interbedded sandstone,

and shale. They have been encountered in structures that are related to down-to-basin structural faults, and exploration of these has yielded many natural gas discoveries. The deeper reservoirs are often overpressured and typically have high flow rates. Reservoirs of normal pressure have also been encountered and are shallower and less costly to drill.

Other plays related to salt piercement structures, stratigraphic traps, and basement related structures, also occur offshore Nova Scotia. Several have produced oil and natural gas shows.

High-quality reflection seismic data are available for the continental shelf and slope. Many geophysical, geological, and well history reports are also available to industry through the Petroleum Resources Section of the Department of Natural Resources.

Discovered Resources and Hydrocarbon Potential

To date, 22 significant discoveries have been made in the Nova Scotia offshore area, mainly in the Sable Sub-basin (Fig. 3). The majority of these discoveries are natural gas and condensate. However, several of these discoveries are producing oil.

It is estimated that 512 billion m^3 (18.1 tcf) of natural gas may exist on the Scotian Shelf and Slope, of which 182 billion m^3 (6.4 tcf) have been discovered to date. Most of this discovered resource is located in natural gas pools that range in size from 7 to more than 40 billion m^3 (0.25 to over 1.4 tcf), with the major discoveries occurring within a 40 km radius of Sable Island. The total oil and condensate estimate is 171 million m^3 (1.1 billion barrels), of which only 34.5 million m^3 (217 million barrels) have been found.

It is estimated that **over 200 undrilled prospects** have been seismically mapped by industry. It is expected that these may yield additional significant discoveries, particularly for natural gas pools with reserves from 6 to 30 billion m^3 (0.20 to 1 tcf). The estimate of 171 million m^3 (1.1 billion barrels) for oil and condensate is also encouraging, although individual pool sizes are predicted to be small.

The Cohasset Project

Canada's first offshore oil project, the Cohasset Project, commenced production on June 3, 1992, thus establishing that production from Nova Scotia's offshore is viable. The project's operator, LASMO Nova Scotia Limited, and Nova Scotia Resources (Ventures) Limited, a provincial Crown corporation, are equal partners in the project. Although the Cohasset and Panuke fields being produced are small by world standards, they can be feasibly developed due to the high productivity, shallow water depth, and moderate climate offshore Nova Scotia. Over the course of the short project, LASMO expects to produce 4.8 million m^3 (30 million barrels) of oil at rates of up to 6370 m^3 (40,000 barrels) per day.

A converted jack-up rig operates as a production facility with a manned wellhead platform at Cohasset, and an unmanned wellhead platform at Panuke. Subsea flow and control lines connect the 11 wells in the two fields. Oil is produced into a storage tanker moored near the Cohasset platform, and the oil is then transported to shore using a smaller shuttle tanker. The product is of high quality and has been sold at a premium price to refiners in the United States and Canada.

Several main components of the offshore facilities were manufactured in Nova Scotia, including production platform decks and the production equipment on the jack-up rig.

Development Opportunities and Markets

Offshore Gas Development and Marketing Studies

In 1992, the Department of Natural Resources commissioned a two-phase Offshore Gas Development and Marketing Study from experienced consultants in the United States and United Kingdom. The results of both phases are available to the industry.

Phase I was designed to identify the most promising field development and market options for offshore natural gas (Fig. 4). It included a technology update of new ideas resulting from North Sea production experience. It investigated the development and marketing of offshore natural gas at rates of 7.1 million m^3/d (250 million standard cubic feet/d) (mmscfd) and 11.3 million m^3/d (400 mmscfd) to natural gas and gas-fired electricity markets. The results of this work suggest that there may be economic merit in producing offshore natural gas after the year 2000. By 2005, combined cycle power generation in the Maritime Provinces could provide an attractive base market to which natural gas or electricity exports could be added, creating sufficient demand to make an offshore natural gas project viable.

Figure: (Not presently available)

Figure 4. Sable Island-Gas Fields (Field Layout Option).

Phase II work was commissioned in 1993. This work expands the range of development and associated marketing scenarios examined in Phase I. Specifically, production and marketing of natural gas at 3.8 million m^3/d (135 mmscfd), 11.3 million m^3/d (400 mmscfd), 17.0 million m^3/d (800 mmscfd) are examined. The principal goal of this work was to provide an integrated analysis of each development and marketing option, starting with realistic market price forecasts and reporting the final results as an after-tax return on investment. All scenarios are economic and bode well for future offshore gas development.

New Areas of Interest

By 1996, the federal and provincial governments must appoint a review panel to examine the environmental and socio-economic implications of oil and natural gas exploration on Georges Bank (Fig. 2), a long-established commercial fishing area. Since a 10-year moratorium was imposed in 1990, scientific studies have been conducted on the unique ecosystem of the bank, and production experience in Nova Scotia's offshore has been gained through the Cohasset Project.

The Laurentian Sub-basin also contains prospective acreage for oil and natural gas potential and could be the site of renewed activity now that the international boundary of St. Pierre and Miquelon is determined. Preliminary studies indicate that if the Scotian Shelf is used as a model, there are some 300 undrilled leads that may have potential.

Resource Management

The federal and Nova Scotia governments share jurisdiction over the offshore area according to the provisions of the ***Canada-Nova Scotia Offshore Petroleum Resources Accord***

Implementation Act and the Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act. This legislation spawned the creation of the Canada-Nova Scotia Offshore Petroleum Board. The Board oversees the day-to-day management of petroleum operations in the offshore area for both governments. However, certain decisions of the Board that are considered "fundamental decisions" are subject to directives and vetoes by the governments.

The Accord gives the provincial government responsibility for, and revenues from, royalties as if the resource were located on the land portion of Nova Scotia. For its first offshore project, the province adopted a royalty regime based on a low fixed rate royalty before project payout and a net profits royalty following payout. It is anticipated that the province will receive approximately $17 million of royalty revenues from the Cohasset Project.

The rights management legislation for Nova Scotia's offshore area is similar to rights management legislation for other Canadian frontier jurisdictions. Three types of petroleum interests may be issued pursuant to the Accord implementation legislation. The most common type of interest, an Exploration License, is issued following a competitive bidding process based upon a single defined criterion, usually work expenditure, and may have a term of up to nine years. If a discovery is made, the legislation provides that the interest owner may apply to the Board for a Declaration of Significant Discovery. If the Declaration is issued, the interest owner is entitled to have a Significant Discovery License issued for the lands to which the discovery extends. If a discovery is designated as a Commercial Discovery by the Board, the interest owner is entitled to a Production License, which has a primary term of 25 years and is extended for as long as commercial production continues.

To encourage investments, the federal and provincial governments have recently repealed the provisions of the implementation legislation requiring that production licenses have a minimum Canadian ownership rate of 50 per cent. These amendments mean that non-Canadian companies have the opportunity to participate on an equal footing with Canadian companies in the production of petroleum resources offshore Nova Scotia.

Back to Top

Onshore

In all, 99 wells have been drilled onshore in Nova Scotia by 22 operators specifically for oil and natural gas. Information derived from these wells has suggested the presence of petroleum in about one-third of them. Another 69 drillholes, drilled for other minerals, have encountered petroleum shows. In 1994, a successful Call for Proposals resulted in exploration licenses for oil and gas being granted on three onshore parcels. More recently considerable attention has focused on coalbed methane. Both activities will result in yet more drilling activity.

Geology

Most onshore petroleum exploration has concentrated on clastic rocks of Carboniferous age (Fig. 5), formed from sediments first deposited in narrow, elongated basins. The first sediments consisted of red and grey sandstone, conglomerate, siltstone and thick grey shales. New Brunswick's Stoney Creek field yielded some 809 million m^3 (28.6 billion cubic feet) (bcf) of natural gas and 127 000 million m^3 (800,000 barrels) of oil from these same sediments.

An overlying evaporite sequence with marine shales contains important source and reservoir rocks. The 1988 Alton natural gas show, which has been the focus of recent industry interest is an example. Exploration agreements have been issued for the lands in the Truro area to permit further evaluation of this prospect.

Significant quantities of mineable coal, along with non-marine red and grey clastics are found in a younger package of rocks. These units are the focus of coalbed methane exploration. The potential of this clean fuel resource is being evaluated.

These sedimentary rocks unconformably overlie older Paleozoic rocks and onlap the older metamorphic basement rocks. The Carboniferous section has both organic-rich source rocks and suitable reservoir rocks. Traps are provided by salt structures, folds, faults, carbonate reef mounds, porosity-permeability pinch-outs, and unconformities.

Source Rocks

Petroleum resources onshore are still uncertain, but new evidence suggests considerable potential in the evaporite sequence of rocks. Previous exploration has focused on the clastic intervals of the underlying rock units for both source and reservoir. A source rock study conducted by the Department of Natural Resources has revealed untested potential in the carbonates and evaporites. More recent work on the geochemistry of oil shows indicates many oils share the characteristics of a common source rock: principally lacustrine carbonates with some links to high salinity depositional environments. Such an interpretation is consistent with the Alton gas show. Such important links may help focus industry's future exploration activity.

Development Opportunities And Markets

Coalbed Methane

Conventional oil and natural gas fields have been exploited for decades. With environmental concerns over the greenhouse effect and unwanted airborne pollutants, there has been an increased focus on cleaner, more environmentally friendly energy sources. Natural gas, in the form of coalbed methane, may well answer many of the difficult questions about the future energy supply in Nova Scotia.

The province has been blessed with a number of prolific coal basins, which have been mined for almost 200 years (Fig. 5). The coals in these basins are of the right age, rank, and type to be considered for their potential to yield this new energy source. An American company, forming a consortium with local companies, has taken out the first exploration agreement in the Cumberland Basin. This basin contains as many as 95 coal seams, some of which have thicknesses of just over 4.0 metres. These seams are coalbed methane reservoir targets. The companies' four-year work program provides for drilling and sampling activities, which will provide new resource estimate numbers for this basin. Their preliminary published estimates speculate as much as 170 billion m^3 (6 tcf) of methane in place for this exploration block.

Other coal basins will be the focus of exploration and assessment. The Stellarton Basin contains the thickest coal seam known in Nova Scotia at just over 14 metres. This basin has been the focus of extensive mining for decades. The potential of this seam, and some 35 others, in providing methane at depths well below conventional mining, have intrigued coalbed methane explorers and developers.

Although the bulk of the coals in the Sydney Basin are developed beneath the Atlantic Ocean, there is potential to extract the methane ahead of, and concurrent with mining operations. A 1993 investigation by the Department of Natural Resources which involved drilling, sampling, and flow testing, indicated that another submarine block of coal has excellent potential to produce methane.

The federal government, in cooperation with the Department of Natural Resources, has allocated $1 million from a federal-provincial Mineral Development Agreement to evaluate the resource potential of coalbed methane in Nova Scotia. Three years of data collection, modelling, drilling, sampling, testing, and analysis will characterize the methane potential of a great number of seams in different coal bearing areas in the province.

Studies Investigating Onshore Petroleum Potential

From the time to time, various projects are undertaken that will result in a better understanding of the geology and subsequent hydrocarbon potential of various areas onshore. The Shubenacadie Basin and St. George's Bay are the current focus of such work by the Petroleum Section. Hopefully, a better understanding of the structure and stratigraphy in these areas should identify geologic features that have the potential for hosting hydrocarbons.

Market Analysis

Onshore methane production could find markets involving several different applications in Nova Scotia. Natural gas is currently unavailable in the province, so the largest single source of current fuel supply to the industrial sector is relatively expensive, imported, refined petroleum products. The average fuel acquisition cost for the 50 largest industrial users in 1991 was $4.41/million British thermal units (mmBtu). Such industrial consumption would require a significant natural gas load: 340,000 m^3/d (12 mmscfd) within a 30 km radius of four centres on mainland Nova Scotia. Large commercial and institutional facilities located throughout the province could create additional demand.

Methane could also be used to power electrical generation facilities designed to supply a single industrial or commercial facility or to feed the provincial electricity grid. The use of methane is particularly attractive when combined with steam sales in a cogeneration facility.

In addition, it may eventually be possible to feed to coalbed methane into an interprovincial pipeline system designed to deliver natural gas from offshore Nova Scotia to external markets. Such a pipeline could be in service early in the next century.

Onshore Call for Proposals

Onshore exploration rights are granted by the province through a competitive Call for Proposals process. The most recent call closed on December 31, 1993. As a result of that call, three new Exploration Agreements (EAs) were concluded. Each of these EAs requires the drilling of at least one well. The exploration period provides adequate time to assess the petroleum potential of each area.

Petroleum Resources Act

Exploration and production rights onshore are governed by the ***Petroleum Resources Act*** and the ***Petroleum Resources Regulations.*** The Act provides for the following types of

agreements concerning exploration and production of oil and natural gas:

- **Exploration License** - This agreement grants a non-exclusive right to explore for petroleum for a term of one year and is intended to allow preliminary exploration to delineate areas of potential.

- **Exploration Agreement** - This agreement confers the exclusive right to explore for petroleum and the exclusive right to apply for a production lease for specified lands. An exploration agreement is usually issued after a Call for Proposals has been held, and has a three-year term renewable for a further three years. It permits the agreement holder to drill deep test wells and to produce oil and natural gas for test purposes. Annual rentals are $0.12 per hectare ($0.05 per acre).

- **Production Lease** - If a commercial discovery is made and the explorer submits a development program acceptable to the Minister, a production lease will be issued for an initial term of 10 years. A production lease grants the lessee the right to produce oil and natural gas from the leased area and to market it according to the regulations. All oil and natural gas marketed is subject to a 10 per cent royalty payable to the province. However, as an incentive to encourage development, the first lease granted from any exploration agreement is exempt from this royalty for the first two years.

- **Coal Gas** - The Petroleum Resources Act defines petroleum to include "coalbed methane" or "coal gas" and vests title to it in the Crown. Rights to explore or produce coal gas for commercial purposes are granted by Coal Gas Exploration Agreements and Coal Gas Production Agreements, respectively. Regulations setting out the procedure for applying for coal gas rights, development program requirements, rentals and other terms and conditions were promulgated in 1987.

Back to Top

In Conclusion

In every respect, Nova Scotia is an attractive area for offshore and onshore exploration and development activities. Nova Scotia contains some of the best frontier oil and natural gas plays yet to be explored in North America. The offshore development of the Cohasset and Panuke oil fields has proven the viability of Nova Scotia as a producing area and has established local infrastructure and a skilled labour force in support of the oil and gas industry. The Department of Natural Resources' offshore natural gas development and marketing studies point to a window of opportunity for natural gas development by 2005. The onshore is the site of significant interest for coalbed methane as well as conventional oil and gas.

Nova Scotia is open for business to the oil and gas industry. We're worth exploring!

For more information on oil and natural gas exploration and development in Nova Scotia, please contact:

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Halifax, Nova Scotia, Canada
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Telephone: 902-424-4575
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Back to: For Further Information at start of article.

Back to Top

Figure: (Not presently available)

Figure 6. Table of Formations.

Back to Top

Photos: (Not presently available)

Cover Photos 1 and 3: Welders at M & M Manufacturing. Courtesy of M & M Manufacturing.

Cover Photo Centre: Canada's first offshore production well at the Panuke Field.

Rowan Gorilla I drilling close to Sable Island. Photo courtesy of Zoe Lucas.

Platform decks for the Cohasset Project being fabricated in the Halifax/Dartmouth area.

Cohasset Project: jack-up rig with production facilities alongside Panuke platform.

Coalbed methane evaluation project, Stellarton Basin.

Underground horizontal drilling to evaluate coalbed methane potential in the Sydney Basin. Photo courtesy of Canmet Cape Breton Coal Research Lab.

Bluenose II entering Halifax Harbour, Nova Scotia. The port of Halifax is the closet major North American port to Europe. Service and manufacturing facilities for offshore exploration and production activities are located nearby. The shipyard has drydocks capable of handling Panamax-size vessels. It is the site of Bedford Institute of Oceanography - the world's second largest oceanographic research centre. Photo courtesy of Nova Scotia Department of Economic Development and Tourism.

Back to Top

Mineral Resources Branch Home Page Natural Resources Home Page

GOV'T. INDEX

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